Applied Occupational and Environmental Hygiene
Volume 17(6): 444–453, 2002

1047-322X/02 $12.00 + .00
DOI: 10.1080/10473220290035480

PDF

A Qualitative Evaluation of Questions and Responses from Five Occupational Questionnaires Developed to Assess Exposures

Patricia Stewart,[1] Carol Rice,[2] Paul Beatty,[3] Barbara Wilson,[3] Walter Stewart,[4] and Aaron Blair[1]

[1]Division of Cancer Epidemiology and Genetics, National Cancer Institute, Bethesda, Maryland;
[2]University of Cincinnati, Cincinnati, Ohio; [3]National Center on Health Statistics, Hyattsville, Maryland;
[4]Johns Hopkins University, Baltimore, Maryland

Questionnaires are increasingly being used in the workplace to assess exposures to chemicals and other agents. Although the literature contains much information on questionnaire design in general, little information is available on the challenges related to questionnaires applied to the occupational setting. Questionnaires on dry cleaning workers, nurses, farmers, car mechanics, and truck drivers were administered to a total of 25 people currently performing one of these jobs. After asking each question, the interviewer probed to identify the difficulties the respondents had in answering the questions. Overall, the respondents were able to answer the questions. Problems were found, however, with particular questions that reduced the effectiveness of the questionnaire. These included the use of unclear terms, questions open to multiple interpretations, difficult computational requirements (e.g., asking for averages for highly variable tasks), ineffective transitions between topics, and overlapping response categories. This type of testing is a crucial part of questionnaire development and can be used to effectively identify potential problems with questions and, therefore, improve them to enhance collection of higher-quality data for assessments of occupational exposures.

Keywords Questionnaires, Occupation, Epidemiology

Interviews to collect information on the occupational setting are conducted for many reasons: to interpret measurement data, to determine justification of workers' compensation cases, to document hazard communication, to assess exposures at a work site, and to investigate current or historical health effects in the context of an epidemiological study. Much has been published on the general principles of questionnaire development[1–3] and qualitative evaluations of the questionnaires; however, little information is available that specifically addresses questionnaires focusing on occupation. Although the general principles for occupational questionnaires may be the same as those for other areas, the difficulty in applying these general principles to specific questions on jobs may not be readily apparent. Moreover, individuals from a specific occupation may interpret questions differently than individuals in another occupation. The need for better questionnaires for epidemiological studies, in particular, has been recognized recently.[4,5]

The questionnaires described here were used in a case-control study of brain cancer[6] to gather lifetime workplace information assessing the probability or likelihood that the respondent had exposure to a particular substance and the probable level of exposure. They appeared, in general, to work well. Because these questionnaires were expected to be used in future studies, however, we conducted a pilot study using a questionnaire development technique known as cognitive interviewing to improve the questionnaire design. Cognitive interviewing relies on responses to in-depth probes to assess question comprehension, the ability of researchers to retrieve information from respondents' memories, and appropriateness of response format, among other issues.[7–9] The purpose of this article is to describe some of the difficulties in the questionnaires.

METHODS

The questionnaires used in this study have been described in more detail elsewhere[6] and were components of a larger questionnaire that collected information on diet, smoking, medications, family history, and other variables. Nurses trained in interviewing techniques administered the questionnaires in person in a hospital in the study for which the questionnaires were developed. Since then they have been used in other studies

by administration by professional interviewers in the homes of study subjects.

The primary occupational hypotheses investigated associations between brain cancer and electromagnetic frequency radiation and solvents, but other exposures of interest were heavy metals, polycyclic aromatic hydrocarbons, machining fluids, and others. The questionnaires were developed to provide better information to industrial hygienists for assessing exposures to these agents compared to the more usual approach of having only job title and industry. They were developed by two industrial hygienists with almost 40 years of experience in a wide spectrum of industries and 20 years in assessing exposures for epidemiological studies, with significant input by two epidemiologists, one of whom had used a similar approach.[10]

To evaluate how respondents interpret and process responses to such questions, five job questionnaires were selected to represent a spectrum of jobs, education levels, and complexity: farmers, nurses, mechanics, truck drivers, and workers in the dry cleaning industry.[11] For each questionnaire, five participants currently employed in one of the five jobs of interest were recruited from the Washington, D.C. area. They were volunteers selected because they were currently holding the job and were thought to be representative of people holding those jobs, with the exception of dry cleaners. The respondents for this job were owners of dry cleaning establishments, because no employees could be found to participate. The majority of the interviews were conducted at the cognitive lab at the National Center for Health Statistics, but some were conducted at the work site or in the home of a respondent. Professional interviewers and researchers with expertise in cognitive interviewing conducted the interviews, which were recorded. Respondents were given $75.

Prior to administering each type of questionnaire, a written protocol was developed that indicated the objectives of the interview, issues, a list of probes associated with each question, and a list of probes asking for subjective reactions to the questionnaire as a whole. After an introduction describing the purpose of the project, the questionnaire was administered to each respondent for his current job. After the respondent answered each question, probes were used to gather information on the respondents' interpretation of the questions, the procedure they used to arrive at their answers, for example, how they calculated frequencies, and their understanding of the purpose of the question. Respondents were encouraged to think aloud while answering each question to provide insight into their thought processes by discussing the basis for their answers, identifying problems they had with the questions, and providing other comments that seemed pertinent to them.[12] The interviews generally lasted about an hour. After each interview, the interviewer compiled observations based on notes taken during the interview and additional analysis of the tape recordings. Interviewers identified instances in which subjects expressed confusion about the meaning of questions, gave responses that were illogical or inconsistent, reported difficulty recalling information asked in the questions, or expressed an interpretation of a question that was inconsistent with its intended meaning. The interviewers met to consolidate their observations and identify what types of cognitive problems could account for these potential errors. Recommendations for question changes were based on these discussions.

RESULTS

Overall, the respondents understood and were able to answer most questions. It was apparent, however, that respondents in different occupations interpreted specific types of questions differently. Examples of these differences are discussed below. The results are presented in the order in which the questions are asked.

Type of Industry

The type of industry is typically sought in interviews because it provides a context for the job and suggests what exposures could occur from the general environment of the workplace. For occupations that occur in a limited number of industries, the questionnaire included possible responses identifying distinct business entities (see Appendix A). Some dry cleaners and vehicle mechanics found that these employer categories were overlapping. Truck drivers indicated that the employer categories did not match their understanding of the type of business. Three selected "a transport/trucking company" even though they were employed by an oil supplier, a trucking company that was owned by a pizza company and only delivered pizzas, and a grocery store chain.

From this evaluation, it appears that the types of employers we provided were more specific than respondents generally consider their employers to be. Possible solutions include asking the respondent which "best" phrase describes the employer or, alternatively, allowing multiple responses.

Identification of Job Tasks

To obtain information on possible exposures generated from tasks, subjects were queried about what tasks they performed and information on the frequency of the task to use in estimating level of exposure. Most respondents found the questions about tasks easy to understand and could provide responses. The respondents performed most of the tasks identified (see Appendix B).

The major issue with this type of question was that respondents sometimes interpreted the terms differently. For example, when farmers were asked if they applied the pesticide themselves, some farmers interpreted "themselves" as meaning that they directly handled the chemicals themselves, while other farmers understood it to mean that application occurred on these farms by any employee on the farm (in contrast to a contracted pesticide applicator). There was also some difference of opinion regarding whether application meant the singular task of applying the pesticide to the crop or animal or other activities associated with application, such as handling the containers and/or mixing the pesticide. In another example, a nurse who

sterilized instruments was not sure whether the question about how much time she spent sterilizing addressed the time she was in the room or the whole sterilization process, including her time out of the room. Truck drivers were not sure whether unloading meant the whole truck or portions of it. The respondents were also unclear as to whether they should indicate a positive response to performing a task if they had only done it once or twice. Better directions to the respondent on how to answer these questions may be helpful but further pilot testing should be conducted.

Frequency of Tasks

For most tasks that occurred consistently and regularly, such as dry cleaning tasks and brake repair, the estimation process appeared easy (Appendix B). The frequency with which tasks were performed was usually ascertained in terms of number of hours per week and weeks per year (in that order). The respondent, however, was permitted to answer in any time unit (minutes or hours per day, week, month, or year). When questioned about the frequency with which tasks were performed, the respondents provided carefully reasoned estimates. When probed, respondents could describe how they got their responses, usually indicating the variability of their tasks by specifying the number of times the tasks were performed and the time spent at each occurrence. Sometimes they described the frequency as "minutes here and minutes there" and estimated this to add up to about an hour a week.

Respondents perceived some tasks, however, as overlapping, so that when the tasks were summed, the total number of hours exceeded 40 hours a week. This problem likely occurred because the tasks were performed almost concurrently or because respondents saw the tasks as a process, rather than individual tasks. For example, the dry cleaners reported they often pressed clothes in between waiting on customers. Farmers perceived applying pesticides as a process rather than as distinct tasks of handling containers, mixing, and applying. Mechanics often did muffler and brake work simultaneously. They could estimate the total time spent on both tasks but they gave the total time as a response for each task, thus doubling the time. Clear identification of what is wanted through use of an introductory sentence may be helpful. Overreporting may also occur because respondents do not know what tasks will be asked about. To prevent overreporting of hours, it may be useful to first identify which tasks were performed and then ask the frequency question about each task. This allows the respondent to obtain a comprehensive picture of what will be covered before requiring him or her to provide estimates of time.

Estimating the frequency of performing tasks was difficult for tasks that were highly variable over the year or when there was no regular schedule for the tasks. For example, farmers had difficulty responding to how many months per year they welded because welding is performed on an as needed basis. They tended to give vague answers such as "every week if necessary" or "not on a regular basis." In other cases, the problem was that the variability was seasonal, such as driving a tractor, repairing auto air conditioners, or unloading heating oil. Clearly, more work is necessary to develop questions that solve this difficult problem.

In some cases the units of time were not clear. For example, some farmers indicated that they drove a tractor 40 weeks a year to the first question (weeks/year) and one hour to the second (hours/week). Other farmers answered the first question as one week because 40 hours is equal to one week. The number of hours a week as the follow-up question then became irrelevant. Days/year also presented similar problems because the respondents did not know whether discrete calendar days were being requested or the total number of eight-hour days. Defining the terms may help this problem.

In contrast to more frequently performed tasks, some less frequently conducted tasks were asked in terms of a unit of time felt to be more appropriate to the task. For some common tasks this format worked well. In other cases, it appeared that the respondent was inadvertently misled by the time units used in the question. Truck drivers were asked how many hours a day they talked into a radio, but because they did not talk much, the respondents interpreted the question to mean the time that the radio was on rather than the number of hours they were actually conversing. It was also clear that there is no single rule that could be applied for identifying units of time (e.g., hours/week). It appeared that units of time that are most appropriate to the task should be selected after probing with possible respondents, but appropriateness may vary by individual. An open-ended question, "How much time did you ..." with the ability to use any response may be more effective.

Chemicals

Although it is recognized that workers are often unable to identify the names of many of the chemicals they used, information on chemicals was requested because we wanted to explore the cognitive process of responding to such questions. Farmers and mechanics generally knew the brand names of the substances with which they worked (see Appendix C). Respondents in other occupations had difficulty with terms for dry cleaning chemicals (dry cleaners), anti-neoplastic drugs and disinfectants (nurses), and lube oils (mechanics).

Multiple names for the same chemical presented problems. When multiple names of the same chemical were listed together—for example, perchloroethylene, perc and tetrachloroethylene—some dry cleaners indicated that they used only one of them. When each name was listed separately other dry cleaners wondered why they were being asked about each because they knew they were the same chemical. Similar problems were found for pesticide generic and brand names. A card handed to the respondent formatted to show the common name and other names may be effective.

We asked how many hours a week the respondents detected the odor of a chemical and the strength of the odor to determine if respondents could provide such information for estimating airborne concentrations. Some problems were uncovered. Two

dry cleaners described a light smell for 45 or more hours a week and three reported a moderate smell for 1 hour a week. By probing, it was found that all five reports could have been describing the same concentration because the first group described the odor associated with the longest duration and the other with the greatest intensity. When truck drivers were asked how often they smelled exhaust, they were not sure whether this referred to the exhaust from their own truck or from other vehicles. Respondents found it difficult to answer the questions on frequency of skin exposure to chemicals. A truck driver hauling oil indicated skin exposure to oil occurred 7–10 times a day; however, once he got the oil on his skin it stayed there for long periods of time. Because he separated the occurrences in his answer the duration of exposure would be estimated to be considerably less than what occurred. Another truck driver initially said 5 times a week, but each time was about 5–6 hours. Defining the terms prior to asking these questions should help in clarifying the information requested.

Equipment

Knowledge of what equipment was used on jobs provides important information on exposures. Electromagnetic frequency exposure, one of the exposures evaluated in the brain cancer study, was thought to be influenced in part by the size of the electrical motor from which the electromagnetic frequency is generated. Subjects were asked if they used three different sized electrical tools and equipment (see Appendix D). The respondents were unsure whether the phrase "use or work near ..." meant working directly with the machine, walking past the machine, or working in the same room or even in the same building as the machine. Near was defined by some respondents to be within a few feet and by others as being six feet or more. One mechanic operated a lathe two to three hours a day but was near electrical equipment only one hour a day (the rest of the time it ran without an operator). Because the dry cleaners in this pilot study moved around a lot, they also had difficulty with the proximity question. The nurses and farmers did not appear to have the same problem, but it is not clear why.

The examples provided of machinery were of little use for some respondents. One farmer called a grain elevator (which is the building in which grain is stored) a medium-sized electrical equipment, although he described the elevator as quite large. (In fact, the elevator itself is not electrical; rather it contains electrical equipment.) One dry cleaner focused only on the example in the question rather than recognizing that the example was for illustration purposes. Quantitative terms should be used rather than subjective terms such as "near" and pictures of equipment used on the job may be more effective.

Farmers were confused about the various types of equipment used to apply pesticides. Some respondents said yes to several application methods, but upon further probing it was found that they were actually referring to only one piece of equipment. In several cases, the farmer could not describe the application methods until they were identified by the interviewer. Pictures of the equipment should reduce confusion over the types of equipment.

Protective Equipment

Only farmers and mechanics were asked about protective equipment, and only during pesticide application and brake repair, respectively (see Appendix E). Asking about use for only these tasks, however, caused confusion because farmers, for example, used the same equipment for other tasks (e.g., gloves were worn by farmers baling hay and they were not clear why we were asking only about use during pesticide application). Most of the terms used to describe the protective equipment, however, were clear to the respondents. Some farmers interpreted leather gloves to mean all gloves but they viewed rubber gloves as being more specific. Many of the respondents wanted to report all of their equipment including boots, helmets, rubber suits, steel-toed shoes, and so on, and were confused as to why these items were not included in the list.

In the mechanic questionnaire, the questions on protective equipment immediately followed the electrical equipment questions. Some of the respondents mistakenly assumed that the use referred only to situations when the electrical machinery was in use, although the question stated we were interested in what was worn while repairing brakes. One respondent, however, assumed the question referred to all tasks. A transition sentence indicating all types of tasks would have helped.

DISCUSSION

This methodological effort was conducted to gain insight into how respondents interpret questions about their jobs and to obtain a qualitative impression of the difficulties they encountered in formulating responses. It was initiated after a report was published of a similar study evaluating questionnaires collecting nutrition information.[13] As in that study, we found several areas of potential confusion.

The questionnaires were developed to classify subjects into four exposure categories for intensity and probability of exposure to a variety of substances. To do this, ideally, it would be useful to have measurement data on the study subjects, as is often the case in cohort studies.[14] In cohort studies, measurements are taken by the study investigators and/or obtained from the employer. Where measurement data do not exist on particular jobs or time periods, the available measurement data often are modified by using determinants of exposure.[15] The difficulty in population-based case-control studies, however, is that the jobs and employers reported by subjects cover the entire country and may have occurred as early as the 1920s or 1930s. Thus, it is impossible to collect measurement data on either the subject or, in most cases, the employer. The only source of exposure information, then, is the study subject, who cannot report what his or her quantitative exposure levels were, even if measurements had been collected.

The historical approach taken to compensate for this dilemma has been to ask study subjects to report their work histories (i.e., jobs, types of business, and dates). Disease risks have then been calculated for each type of job and/or employer. This approach is limited, among other reasons, because possible causative agents are not identified prior to the analyses, making associations with exposures speculative.[16] To overcome this limitation, job exposure matrices (JEMs) were developed to identify exposures before the analysis. In JEMs, however, all subjects holding the same job are assigned the same exposure. Recently, it has been recognized that this approach does not allow for the variability of exposure within jobs or companies within an industry. Ignoring this variability can result in a severe lack of statistical power for detecting disease-exposure associations.[17] Hence, detailed questionnaires were developed.

In the epidemiological study for which the questionnaires described in this report were developed, published measurement data were used to establish an overall mean exposure level for a job/industry. The mean was then modified, based on the information on tasks and equipment, the frequency of the tasks, level of ventilation, and so on, from the questionnaires. Thus, the questionnaires were crucial in the development of the exposure estimates.

It is recognized, however, that questionnaires are likely to result in less accurate exposure estimates than using measurements. One source of the inaccuracy is the questionnaire and how it is interpreted. It is critical, therefore, to understand how respondents formulate responses, and this was the reason for the study.

Exploring the cognitive processes used by respondents, however, is only the first step in questionnaire validation. After being assured that a questionnaire gathers information effectively and minimizes errors in reporting, the investigator must then validate the information and the exposure assessment process.[9] This requires assessment of the questionnaires by an industrial hygienist for comparison with exposure data. Few studies have been published reporting such comparisons. One study where industrial hygienists assessed questionnaire information for definite, probably, possible, and unlikely exposure to asbestos found the median number of asbestos fibers in the lung of surgical patients to be 5.6, 0.6, 0.3, and < 0.3 fibers, respectively.[18] Similar results were found comparing the probability of exposure of autopsied patients to asbestos counts.[19] Studies investigating how well industrial hygienists assess exposures without measurement data have found mixed results.[20,21] Even with a few data, however, industrial hygienists perform much better.

Some investigators question whether questionnaires can be used to investigate exposure-response relationships. This may not, however, be the appropriate question. Rather, we should be determining whether using detailed questions to assess occupational exposures does a better job than using the more traditional methods of job titles or JEMs to investigate occupational disease risks. In a recent study investigating this issue, exposures estimated from questionnaires similar to those described in this paper were found to have low to moderate agreement with biological markers of exposure (kappa = 0.26–0.37).[22] The agreement, however, was higher than that of the more traditional approaches of assessing occupational exposures (kappa = 0.08–0.24). These findings suggest that questionnaires may be used to develop more accurate estimates of exposure, but more research is necessary to develop effective and valid questionnaires for exposure assessment in the occupational setting. The suggestions described here should be tested against the original questions to provide information as to which approach increases the validity of the collected data.

REFERENCES

1. Sudman, S.; Bradburn, N.M.: Asking Questions. Jossey-Bass Publishers, San Francisco (1987).
2. Converse, J.M.; Presser, S.: Survey Questions: Handcrafting the Standardized Questionnaire. Sage Publications, Beverly Hills, CA (1986).
3. Payne, S.: The Art of Asking Questions. Princeton University Press, Princeton, NJ (1951).
4. Olsen, J.: Epidemiology Deserves Better Questionnaires. Inter J Epidemiol 27:935 (1998).
5. Wilcox, A.J.: The Quest for Better Questionnaires. Amer J Epidemiol 150:1261–1262 (1999).
6. Stewart, P.A.; Stewart, W.F.; Siemiatycki, J.; et al.: Questionnaires for Collecting Detailed Occupational Information for Community-Based Case-Control Studies. Amer Indus Hyg Assoc J 59:39–44 (1998).
7. Willis, G.B.; Royston, P.; Bercini, D.: The Use of Verbal Report Methods in the Development and Testing of Survey Questionnaires. App Cogn Psychol 5:251–267 (1991).
8. DeMaio, T.J.; Rothgeb, J.M.: Cognitive Interviewing Techniques: In the Lab and in the Field. In: N. Schwarz and S. Sudman (Eds.), Answering Questions: Methodology for Determining Cognitive and Communicative Processes in Survey Research. Jossey-Bass, San Francisco, CA (1996).
9. Bercini, D.H.: Pretesting Questionnaires in the Laboratory: An Alternative Approach. J Exp Anal Environ Epidemiol 2:241–248 (1992).
10. Siemiatycki, J.: Risk Factors for Cancer in the Workplace. CRC Press, Boca Raton, FL (1991).
11. Beatty, P.; Wilson, B.; Guadagno, M.A.: Cognitive Testing of NCI Occupational Exposure Questionnaires. National Center for Health Statistics, Hyattsville, MD (1996).
12. Ericsson, K.A.; Simon, H.A.: Verbal Reports as Data. Psychol Rev 87:215–251 (1980).
13. Subar, A.F.; Thompson, F.E.; Smith, A.F.; et al.: Improving Food Frequency Questionnaires: A Qualitative Approach Using Cognitive Interviewing. J Amer Diet Assoc 95:781–788 (1995).
14. Stewart, P.A.; Stewart, W.F.; Heineman, E.F.; et al.: A Novel Approach to Data Collection in a Case-Control Study of Cancer and Occupational Exposures. Inter J Epidemiol 25:744–752 (1996).
15. Stewart, P.; Stenzel, M.: Exposure Assessment in the Occupational Setting. Appl Occup Environ Hyg 15:435–444 (2000).
16. Stewart, P.A.; Herrick, R.F.: Issues in Performing Retrospective Exposure Assessment. Appl Occup Environ Hyg 6:421–427 (1991).

17. Dewar, R.; Siemiatycki, J.; Gerin, M.: Loss of Statistical Power Associated with the Use of a Job-Exposure Matrix in Occupational Case-Control Studies. Appl Occup Environ Hyg 6:508–515 (1991).
18. Karjalainen, A.; Anttila, S.; Vanhala, E.; Vainio, H.: Asbestos Exposure and the Risk of Lung Cancer in a General Urban Population. Scand J Work Environ Health 20:243–250 (1994).
19. Karjalainen, A.; Vanhala, E.; Karhunen, P.K.; et al.: Asbestos Exposure and Pulmonary Fiber Concentrations of 300 Finnish Urban Men. Scand J Work Environ Health 20:34–41 (1994).
20. Post, W.; Kromhout, H.; Heederik, D.; Noy, D.; Duijzentkunst, R.S.: Semiquantitative Estimates of Exposure to Methylene Chloride and Styrene: The Influence of Quantitative Exposure Data. Appl Occup Environ Hyg 6:197–204 (1991).
21. Hawkins, N.C.; Evans, J.S.: Subjective Estimation of Toluene Exposures: A Calibration Study of Industrial Hygienists. Appl Indus Hyg 4:61–68 (1989).
22. Tielemans, E.; Heederik, D.; Burdorf, A.; et al.: Assessment of Occupational Exposures in a General Population: Comparison of Different Methods. Occup Environ Med 56:145–151 (1999).

APPENDIX A

Issues with questions on type of industry[A]

Job	Question	Problem[B]
Dry cleaner	Did you work in a. a laundry that washed clothes only with water and that did not dry clean clothes? b. a retail dry cleaner or laundry where dry cleaning was done only at the place where you worked? c. a retail dry cleaner or laundry that sent clothes out for dry cleaning? d. a dry cleaning plant? e. another type of business? (specify)	Overlapping responses (b, c, d)
Vehicle mechanic	What type of business was (name), that is, what did the company make or what service did they provide? (CIRCLE ALL THAT APPLY) A. AUTO/CAR DEALER B. GAS OR SERVICE STATION C. GENERAL GARAGE D. BRAKE REPAIR GARAGE E. OTHER SPECIALTY GARAGE (MUFFLER, TIRE LUBE, ETC). F. SERVICE PROVIDER OTHER THAN GARAGE OR CAR DEALER G. OTHER (SPECIFY)	Overlapping responses (C, D, and E)
Nurse	What type of business was (name)? A. HOSPITAL B. CLINIC C. DOCTOR'S OFFICE D. HOME CARE NURSING ORGANIZATION E. SOMETHING ELSE (SPECIFY)	No problems
Farmer	(Not asked)	—
Truck driver	Did you work a. as an independent driver/trucker? b. for a transport/trucking company? c. for a manufacturer? d. for a local, state, or federal government? e. for any other type of company?	Unclear terms

[A]Capital letters in response indicates response was designed in a real study to be available to the interviewer but not to the respondent. The responses were discussed as part of the pilot study, however, after the respondent had answered the question.
[B]Responses that overlapped are in parentheses.

APPENDIX B

Issues with questions on tasks and their frequency[A]

Job	Question	Problem[B]
Dry cleaner	Did you do any of the following: a. Wait on customers? b. Press clothes? c. Spot clean? d. Transfer dry-cleaned clothing from the washer to the dryer? e. Manually transfer dry cleaning chemicals from a storage tank to a washer? f. Clean or maintain the dry cleaning equipment?	No problems
	How many hours a week did you (above task)? How many weeks a year did you (task)?	Concurrent tasks (b, c) resulted in double counting of hours
Farmer	Did you a. **Apply** herbicides (insecticides) on crops **yourself**? b. Apply insecticides on animals?	Unclear terms
	On average how many **days** a year did you apply (herbicides/insecticides)?	Unclear term
	On average how many months a year did you a. apply fertilizers? b. weld? c. solder? d. do carpentry work? e. paint? f. treat wood? g. repair or maintain equipment?	Difficult to estimate seasonal tasks
	On average how many hours a month during those months did you (task)?	
	How many weeks a year did you drive a tractor or other farming equipment?	Unclear terms; difficult to estimate highly variable tasks; differing interpretations
	During those weeks how many hours a week did you, on average, drive a tractor or other farming equipment?	
	How many times a week did you fill the fuel tanks of your tractor or other equipment with diesel? Gasoline?	No problems
Vehicle mechanic	Did you a. do muffler work? b. do transmission repair? c. do brake work? d. do tune-ups? e. do major engine overhauls? f. repair air conditioning and cooling systems? g. body work? h. paint? i. pump gas? j. do any other type of work? (specify)	No problems
	On average how many hours a week did you do (task)?	Overlapping tasks (a, c); difficult to estimate seasonal variability (f)
	What did you use to clean your hands? On average, how many times a week did you use (chemical) to clean your hands?	No problems

(Continued on next page)

APPENDIX B

Issues with questions on tasks and their frequency[A] *(Continued)*

Job	Question	Problem[B]
Nurse	How many times a week did you personally a. **sterilize** instruments or other equipment? b. use disinfectants? c. work near an x-ray machine or other type of imaging radiation? d. work with any other sources of radiation such as radioisotopes, MRI, or CAT scan equipment? e. use talcum powder on your patients or in your gloves? f. purge IVs or syringes of anti-neoplastic drugs? g. operate **diathermy** equipment?	Unclear terms
Truck driver	Were you involved in **loading** your truck?	Unclear term
	Which of the following jobs did you do? a. Oil changes b. Tune-ups c. Brake repair	No problems
	How many hours a year did you do (task)?	No problems
	On average how many hours a week did you talk into a radio installed in the truck?	Misleading time units

[A]Words in bold indicate the unclear term.
[B]Responses that overlapped are in parentheses.

APPENDIX C

Issues with questions on chemicals[A]

Job	Question	Problem[B]
Dry cleaner	Which of the following dry cleaning chemicals were used to dry clean? a. Perchloroethylene, perc, or tetrachloroethylene b. Gasoline c. Trichloroethylene or TCE d. Carbon tetrachloride or carbon tet e. Stoddard solvent f. Petroleum distillates g. Anything else (specify)	Overlapping responses (a)
	How many hours a week on average did you have **dry cleaning chemicals** on your hands?	Unclear terms
	On average how many hours a week could you smell dry cleaning chemicals? How strong was the smell? Was it a. light? b. moderate? c. heavy?	Differing interpretations
Farmer	What (herbicide/insecticide) did you apply? (A list of 22 herbicide and 15 insecticide brand and chemical names was provided.)	Most knew brand names; overlapping responses
Vehicle mechanic	Did you use **lube oils** and greases? Hydraulic fluids (brake/transmission)? How many hours a week did you use lube oils and greases? Hydraulic fluids?	Unclear terms
	What chemicals did you use to clean, strip, or degrease parts?	Most knew brand names
Nurse	How many times a week did you personally a. sterilize instruments or other equipment? b. use **disinfectants**? c. work near an x-ray machine or other type of imaging radiation? d. work with any other sources of radiation such as radioisotopes, MRI , or CAT scan equipment?	Unclear terms (b, f)

(Continued)

APPENDIX C

Issues with questions on chemicals[A] *(Continued)*

Job	Question	Problem[B]
	e. use talcum powder on your patients or in your gloves?	
	f. purge IVs or syringes of **anti-neoplastic** drugs?	
	g. operate diathermy equipment?	
Truck driver	How many times did you get it (material being loaded) on your skin?	Difficult to estimate
	How many hours a week did you smell **exhaust while driving**?	Unclear terms

[A]Words in bold indicate the unclear term.
[B]Responses that overlapped are in parentheses.

APPENDIX D

Issues with questions on equipment[A]

Job	Question	Problem[B]
Dry cleaner	How many of the following types of dry cleaning machines were there?	No problems
	a. Transfer type (count the number of washing machines)	
	b. Dry-to-dry (washer/extractor/dryer is one machine)	
	How many hours a day did you	Unclear terms; difficult to estimate when subject not stationary; focused on examples, not general question
	a. use a handheld electrical tool such as a household iron?	
	b. use or **work near** a medium-sized electrical machine or equipment about the size of a household washer or dryer?	
	c. use or **work near** heavy-duty industrial electrical equipment larger than a household washer or dryer, such as a large steam ironer?	
Farmer	How did you apply the (herbicide/insecticide)?	Overlapping responses (A, B, C); unclear terms (A, B, E)
	A. BACKPACK	
	B. TRUCK WITH HANDHELD SPRAYER	
	C. WALKED WITH HANDHELD SPRAYER	
	D. PLANE	
	E. BOOM IN BACK OF TRUCK OR EQUIPMENT	
	F. OTHER (SPECIFY)	
	How many hours a day did you	Unclear term
	a. use a handheld electrical tool such as an electric saw?	
	b. use or work near a medium-sized electrical machine or equipment about the size of a household washer or dryer?	
	c. use or work near **heavy-duty industrial electrical equipment larger than a household washer or dryer**?	
Vehicle mechanic	How many hours a day did you	Unclear terms
	a. use a handheld electrical tool such as a grinder?	
	b. use or **work near** a medium-sized electrical machine or equipment about the size of a household washer or dryer?	
	c. use or **work near** heavy-duty industrial electrical equipment larger than a household washer or dryer?	
Nurse	How many hours a day did you	No problems
	a. use a handheld electrical tool?	
	b. use or work near a medium-sized electrical machine or equipment about the size of a household washer or dryer, such as an ultrasound or stress test machine?	
	c. use or work near heavy-duty industrial electrical equipment larger than a household washer or dryer, such as an x-ray machine?	

[A]Capital letters in response indicates response was designed in a real study to be available to the interviewer but not to the respondent. The responses were discussed as part of the pilot study, however, after the respondent had answered the question. Words in bold indicate the unclear term.
[B]Responses that overlapped are in parentheses.

APPENDIX E

Issues with questions on protective equipment[A]

Job	Question	Problem[B]
Dry cleaner	(Not asked)	—
Farmer	Did you wear any protective clothing, such as gloves or masks? What clothing did you wear? A. LEATHER GLOVES B. RUBBER OR OTHER GLOVES C. A MASK OR RESPIRATOR D. AN APRON E. OTHER PROTECTIVE CLOTHING For what tasks? A. APPLYING HERBICIDES B. APPLYING INSECTICIDES ON CROPS C. APPLYING INSECTICIDES ON ANIMALS D. MIXING INSECTICIDES/HERBICIDES E. OTHER (SPECIFY)	Unclear terms (A, B)
Vehicle mechanic	Did you wear protective clothing or gear while repairing brakes? What protective clothing or gear did you use? A. HEADGEAR B. FOOTGEAR C. GOGGLES D. GLOVES E. APRON F. FACE SHIELD G. FILTER CARTRIDGE RESPIRATOR H. AIR-SUPPLIED/SCUBA-TYPE RESPIRATOR I. DUST MASK J. OTHER (SPECIFY)	Poor transition
Nurse	(Not asked)	—
Truck driver	(Not asked)	—

[A]Capital letters in response indicates response was designed in a real study to be available to the interviewer but not to the respondent. The responses were discussed as part of the pilot study, however, after the respondent had answered the question.

[B]Responses that overlapped are in parentheses.